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Observation of Snowfall over Land by Microwave Radiometry from Space

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***Abstract* - High frequency (ν > 100 GHz) observations from AMSU-B during the March 5-6, 2001 New England blizzard are used to investigate the detection of snowfall over land. The AMSU-B data are compared to NEXRAD reflectivities. The radiative effects of a snow model are compared with observations. Low altitude water vapor is shown to obscure emission from the underlying ground at high frequencies, but at high altitudes water vapor also reduces the impact of scattering by snow particles.**

1. INTRODUCTION

Although most global precipitation occurs as rainfall, snowfall plays a significant role in the extra-tropical hydrological cycle. Snow serves as a reservoir of water that can be released later in the year to support agriculture and hydroelectric activities. Beside the economic and recreational value of snow, snow storms can be hazardous for transportation and other economic activities. One of the important challenges for future satellites is to detect these snow storms from space.

Because snow accumulation on land affects the emission properties of the surface, the measurement of snowfall within the atmosphere has been difficult with radiometers that operate at frequencies less than 100 GHz. Water vapor absorption at frequencies greater than 100 GHz can screen the emission from snow covered surfaces. The Advanced Microwave Sounding Units (AMSU-B) radiometers on the NOAA 15 and 16 spacecraft [1] provide observations at 89, 150 and 183$\pm$1, $\pm$3, $\pm$7 GHz. This study will demonstrate that radiation at those higher frequencies can be used to measure snowfall over land because water vapor screening obscures the underlying snow-covered surface.

The AMSU-B radiometer on NOAA-15 initially encountered radio frequency interference from on-board transmitters that were ultimately shut down in the autumn of 1999. Modifications were implemented on the NOAA-16 AMSU-B so that reliable spaceborne data at frequencies greater 100 GHz were available by the winter of 2000-01.

2. CASE STUDY

The Nor'easter of March 5-6, 2001 presented a unique opportunity to observe intense snowfall over land with the NOAA-16 AMSU-B. That blizzard was one of the more intense snow storms of the season, depositing on the order of 50 cm of snow on much of VT, NH and northeastern NY with several stations reporting deposits of 75 cm. Wet snow and sleet were reported along the New England coast, but the mean temperatures encountered in NH and VT remained around –5 C, and reported maxima were only –2 C, so that melting could be disregarded over inland regions throughout the entire day.

Fig. 1 shows a composite of the National Weather Service (NWS) operational weather radar reflectivity, Z_{eff} (dBZ) obtained over the Northeastern U.S. on March 5, 2001 at 23:00 UTC. The snowfall was greatest over CT, MA, VT, and NH. Although the NWS operational radar data have well known limitations, in the absence of a preplanned field observation campaign, they provide readily available data to compare to snowfall derived from microwave brightness temperatures.

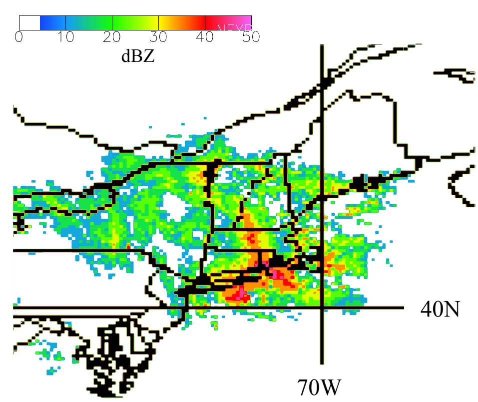

Figure 1: NWS NEXRAD reflectivities for March 5, 2001 2300 UTC.

4. SUMMARY

In summary, the NEXRAD and AMSU-B 150 and 183 GHz channels were found to be qualitatively related to the coincident NEXRAD radar data. Furthermore, an appropriate snow particle model was found to match attenuation measurements of snow and the issues surrounding surface emissivity were addressed. A process is underway to more fully characterize the relationships between the higher frequency brightness temperatures and the snow in the cloud profile.